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TOMATO DISEASES IN INDIANA

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Septoria blight or leafspot, one of the chief causes of defoliation of field-grown tomatoes in Indiana.

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The six most important diseases of field grown tomatoes in Indiana are: Septoria blight, early blight, anthracnose, bacterial spot, bacterial canker and Fusarium wilt. At least fifteen others, including bacterial wilt, southern root rot, leaf mold, buckeye rot, soil rot, the four virus diseases, mosaic, streak, ringspot and fernleaf, and such miscellaneous troubles as damping-off, root knot or nematodes, blossom-end rot, cloudy spot, walnut wilt, and even lightning injury, also occur.

Control of most of these diseases in the state involves (1) the production and use of disease-free seed and transplants, (2) setting the transplants in fields that are as free as possible of the disease-producing agents, and (3) subsequent protection of the plants from leaf blights and fruit rots by spraying or dusting with suitable fungicides.

Disease-free tomato seed may be obtained by extracting it from sound, edible fruits produced on plants free of bacterial canker infection. Such seed should be washed, fanned and screened thoroughly to remove all dead, light, cracked and small seeds, and should be treated with a suitable disinfectant, such as 1:2,000 mercuric chloride or 1:1,200 New Improved Ceresan.

Disease-free transplants can be grown in greenhouses, hotbeds and coldframes, or in open beds and fields under the proper conditions of sanitation, fertilization, temperature and moisture supply.

Transplants should be set out just as soon as they reach the proper size and condition for transplanting, in order to reduce the chances of disease infections taking place in the beds or plant fields.

Leaf blights and fruit rots may be materially reduced by spraying or dusting the plants at suitable intervals after transplanting. Such control may prove profitable in Indiana in seasons when the rainfall is normal or above during the months of June, July and August.

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TOMATO DISEASES IN INDIANA

R. W. Samson¹ and H. Rex Thomas²

The important diseases that occur on canning tomatoes in Indiana are caused by specific bacteria, fungi and viruses, in the absence of which the diseases would not develop. The fungi and bacteria are living organisms capable of attacking the tomato plant or fruit and causing disease. They persist from year to year in or on old plant debris, in the soil or sometimes on other plants besides the tomato. They may be disseminated with the seed or in infested soil and plant debris. The tomato viruses are not seed-borne but may live over from season to season in perennial or winter annual plants. Winds, dashing rains, insects, handling of plants, cultivation and harvesting practices all play a part in the spread of these various disease-producing agents. Moderate temperatures, frequent rains and dews favor the development of the diseases as well as the growth of the tomato.

It is the purpose of this circular to outline practices that are of value in preventing losses due to these diseases in Indiana and to present concise descriptions of the diseases so that growers, canners, and canners' fieldmen can identify them and understand the manner in which preventive measures operate. Such preventive or control measures are most effective when incorporated into the general procedure involved in growing a crop of tomatoes and are, therefore, outlined in some detail in the first part of this circular. Their specific applications are pointed out in connection with the descriptions of the individual diseases.

These measures involve the production and use of disease-free seed and transplants, the setting of such transplants into fields that are as free as possible of the various disease-producing agents, and the subsequent protection of the plants from disease by spraying or dusting with suitable fungicides. The use of disease-resistant varieties is another means of disease control that is of limited value at present since very few tomato varieties have been developed that possess satisfactory resistance to the important tomato diseases.

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THE CONTROL OF TOMATO DISEASES

Production of Disease-Free Tomato Seed

There are two principal ways in which important diseases of tomatoes in Indiana may be transmitted with the seed. Certain of the disease-producing organisms, particularly those causing bacterial canker, (Figs. 5, 6, 7), Fusarium wilt (Figs. 1, 2), and early blight fruit rot (Fig. 10), may penetrate a few seeds under favorable conditions and be transmitted internally. These and other disease-producing organisms may become attached to the seed coats during the extraction process and be carried externally. Under Indiana conditions it has been found possible to produce disease-free tomato seed by the following three practices: (1) Selection of seed fields free of plants infected with bacterial canker and practically free of plants infected with Fusarium wilt; (2) saving seed only from fruits that are sufficiently sound to permit their use in the manufacture of tomato juice, puree, or canned whole tomatoes; (3) treatment of the seed with a suitable surface disinfectant.

Observations made on 18 lots of certified tomato seed produced in Indiana during the years from 1934 to 1939 indicate clearly that it is possible to obtain seed free of internal infection with bacterial canker by saving it only from fields selected for freedom from infected plants. Seed transmission of Fusarium wilt and early blight appears to play a very minor part, if any, in the occurrence of these diseases in Indiana. Moreover, it is comparatively easy to produce seed free of the wilt and early blight organisms. Very few edible fruits produced on wilt-infected plants contain seeds internally infected with the wilt organism. Usually the fruits become rotten and unfit for processing before the fungus advances sufficiently into the fruits to infect many seeds. Furthermore, very few fruits are harvested from wilt-infected plants and delivered to the canning factory.

The early blight disease is of almost universal occurrence in tomato fields during the harvesting season so that it is impossible to select seed fields free of the disease. The disease occurs as a fruit rot as well as a leaf spot and stem canker (Figs. 8, 9, 10). The fruit rot may involve some of the seed cells and the fungus may penetrate a few of the seeds. Most of such fruits are sorted out in the manufacture of tomato juice, puree or in canning whole tomatoes. Seed saved from the waste pomace at the ends of juice or pulp lines in canning factories, or sometimes from the waste from the filling benches where whole tomatoes are being packed into cans, is practically free of internal infection by the early blight organism. The subsequent washing, flotation, drying and fanning operations involved in cleaning the seed eliminates small, light and dead seeds, such as may be produced in diseased fruits.

The practices of taking seed only from fields free of bacterial canker and from only such fruits as are fit for manufacture thus effectively eliminate disease-producing organisms borne within the seed. Several seed treatments have been found that effectively eliminate those organisms attached to the surface of the seed.

Tomato Seed Treatments

Tomato seed should be treated with a suitable fungicide for two reasons. The first is to rid the seed of disease-producing organisms that may be adhering to the seed coats. The second is to deposit a disinfectant material on the seed coat which will protect the young seedlings from various organisms naturally present in most soils and which blight the young seedlings before they emerge, or attack them at the ground line after they emerge and cause them to "damp-off." Sometimes, both objectives of seed treatment may be attained with a single material, which obviates the necessity of two different seed treating operations. The following seed treatments have given good results on tomato seed planted in greenhouses, hotbeds, coldframes, or in the open in all parts of Indiana. The specified chemicals can be secured at most leading drug stores and seed stores.

Mercuric chloride

The most satisfactory tomato seed treatment under Indiana conditions appears to be, first, to soak the seed for 5 to 10 minutes in a 1:2,000 solution of mercuric chloride, in order to kill seed-borne, disease-producing organisms, and then follow with the copper sulphate or cuprous oxide treatments to protect the young seedlings from damping-off or seedling blights. Mercuric chloride may be obtained from most drug stores as a white, granular salt or as blue-colored tablets. It is also known as corrosive sublimate or bichloride of mercury and is highly poisonous. Care must be taken to prevent it from being eaten by humans or animals. Workers should avoid any prolonged exposure of the skin to solutions of mercuric chloride and should not breathe the dust from treated seed.

The treating solution should be used in earthenware or wooden containers, since mercuric chloride corrodes metals.

A 1:2,000 concentration of mercuric chloride may be obtained by dissolving one ounce of the granular form in each 15 gallons of water or one blue corrosive sublimate tablet in each quart of water. The temperature of the treating solution should be between 70° and 90° F. for best results.

The seed should be as free of foreign matter as possible, with no peeling or inert material sticking tightly to the seed coats so as to prevent the solution from coming in contact with all seed surfaces. Freshly extracted seed should be drained, pressed or centrifuged free of excess water before it is treated. Not more than one pound of dry seed or one quart by volume of wet seed should be treated in each gallon of solution. The seed must be free in the solution and not held in a cloth bag, which would interfere with thorough disinfection. After soaking for 5 to 10 minutes, with constant stirring, pour the seed into a bag and allow to drain for a few minutes. Then press or centrifuge it free of excess solution and spread out to dry. The seed need not be rinsed with water subsequent to treatment. Do not reuse the treating solution but dispose of it where persons or animals can not drink it or where it will not come in contact with foods.

Copper sulphate

Increased stands and somewhat more vigorous seedlings have been secured consistently in greenhouse and outdoor tests in Indiana from tomato seed treated by soaking for an hour in a solution of two ounces of copper sulphate or bluestone per gallon of water. Copper sulphate corrodes iron so it should be used in wooden or earthenware containers. The temperature of the solution should be between 70° and 90° F., and the volume of seed treated per gallon of copper sulphate solution should be the same as for the mercuric chloride treatment. Copper sulphate may be used to advantage on seed that has been treated previously with mercuric chloride, and can be applied immediately following the mercury treatment. The mercury treatment effectively rids the seed of surface-borne fungi and most bacteria but does not protect the young seedlings from soil-borne seedling blights or damping-off as well as do copper treatments. Copper sulphate kills bacteria on the seed surfaces and gives the young seedlings substantial protection from damping-off.

The increased vigor of young seedlings from seed treated with copper sulphate has been most marked under greenhouse conditions and may not be so apparent under outdoor conditions. Tomato seed treated with mercuric chloride and then treated with copper sulphate is well worth trial in direct seeding of tomato fields.

Cuprous oxide

Tomato seed dusted with cuprous oxide, also known as red copper oxide, has usually given better stands of seedlings than untreated seed or seed treated with mercuric chloride when planted in the greenhouse or outdoors in Indiana. Like copper sulphate, it can be applied to tomato seed that has been treated with mercuric chloride. It can be used safely, under Indiana conditions, on seed previously treated with ethyl mercury phosphate as outlined below. Tomato seed is easily treated with cuprous oxide by thoroughly mixing the two together in a suitable closed container. It should be used at the rate of two pounds of cuprous oxide to each 100 pounds of tomato seed, or 1½ teaspoonsful per pound. Thorough mixing is important and a good grade of cuprous oxide prepared for seed treatment should be used.

Ethyl mercury phosphate

Tomato seed treated in a dilute solution of a poisonous, organic mercury compound known as ethyl mercury phosphate appears to be more completely disinfected than when treated with any of the other three materials. In tests at Purdue, tomato seed treated with this material has always germinated more slowly than untreated seed or seed treated with mercuric chloride, copper sulphate or red copper oxide, although the final germination has usually been satisfactory. This delay in germination is more noticeable shortly after the seed has been treated than after the treated seed has been stored for from 6 to 18 months. Germination tests should be made in sand or soil since tomato seed treated with this material does not germinate satisfactorily on blotting paper.

Ethyl mercury phosphate is available commercially in the preparation known as New Improved Ceresan, which contains 5 percent of the mercury compound mixed with talc. It is used extensively for the treatment of seed wheat and oats. It is prepared for tomato seed treatment by suspending one ounce of the commercial dust in nine gallons of water in a wooden or earthenware container. This makes a 1:1,200 suspension of the commercial dust or a 1:24,000 solution of the active ethyl mercury phosphate. The cleaned, freshly extracted or dried tomato seed is soaked in this solution for from 5 to 10 minutes with constant stirring, then flushed into a bag and allowed to drain for a few minutes, after which it is pressed or spun free of excess solution and spread out to dry. Not more than one pound of dry seed or one quart by volume of wet seed should be treated in each gallon of treating solution. Do not reuse the solution but dispose of it where humans or animals can not drink it. Workers should wear rubber gloves while handling the solution or the wet, treated seed, and should avoid breathing the dust from the treated dry seed.

Disease-Free Tomato Transplants

Diseases introduced into tomato fields on transplants may develop into epidemics much sooner than when they came from other sources. Thus, disease-free transplants are highly important. Transplants for the home, greenhouse and market garden crops are usually started in greenhouses, hotbeds, or coldframes. The seedlings are transplanted at least once before being set in the permanent bed, garden, or field. Few of the transplants used for canning tomatoes are started in this way. For the most part the seed is sown in open fields in southern states. The plants from such fields are subsequently pulled and shipped to northern canning areas where they are set directly in the field without an intermediate transplanting operation.

Control of transplant diseases in greenhouses, hotbeds, and coldframes

Good tomato transplants can be grown by starting the seedlings in greenhouses and hotbeds and subsequently transplanting to pots, coldframes, etc., before setting in the field. Disease hazards are great under such a system of transplant production, however. Most such growing sites are subject to contamination from diseased tomato material so that extreme care is needed in disinfecting the soil, beds, frames, or in moving the beds to uninfested locations each season. The extra handling of the seedlings and transplants often results in extensive spread of mosaic if any infected plants occur in the plantings. On the other hand, the rate of growth of such plants can be controlled more satisfactorily so that it is easier to have the plants in the desired condition for transplanting at the proper time.

Plant Bed Disinfection

Greenhouse benches, flats, hotbed frames, cold frames and soil may be disinfected by drenching with a strong formaldehyde solution made up of one gallon of commercial, 40 percent formaldehyde (or formalin) in each 24 gallons of water. Apply the solution to the soil at the rate of one quart to each square foot and at least two weeks prior to planting of

the seed or setting of seedlings. Water heavily following treatment so as to wash the formaldehyde into the soil and cover with canvas, roofing paper or glass sash for a week. Uncover for a week, working the soil to allow the formaldehyde to escape before sowing the seed.

Such soil disinfection may not be necessary if clean soil is available or if the disinfected frames and sash can be moved to new, disease-free locations each year. If non-disinfected soil is used the tomato seed should be treated with copper sulphate or cuprous oxide to protect the young seedlings from damping-off organisms that are naturally present in most soils.

Plant Bed Management

Where tomato transplants are grown in greenhouses, hotbeds or cold-frames it is very important that adequate ventilation be provided at all times in order to maintain a low humidity and moderate temperature of the air around the plants. All watering should be done in the morning so that the plants and the surface of the soil will dry off as quickly as possible. Too much moisture in the surface soil will favor damping-off. If damping-off appears after the seedlings emerge it can be controlled by drenching the soil surface with a suspension of cuprous oxide made up at the rate of $1\frac{1}{2}$ pounds in 50 gallons of water.

Control of diseases in field-grown transplants

Most of the transplants used for canning tomatoes in Indiana are grown in open beds or fields. Some are grown near the canning factories principally for resetting purposes. Others are grown in the southern part of the state, both for local can-crop fields and for shipment to cannery in the north-central part of the state. The bulk of the transplants, however, are grown in open fields in southern states. The seed is sown in rows sufficiently far apart to permit cultivation. Care should be taken to select fields that have not been contaminated by previous tomato crops, or other crops susceptible to tomato diseases, or by run-off water or other means whereby diseased material may be transported. In many sections of the southern states the soils are infected with nematodes which have multiplied on cotton, tobacco, sweet potatoes, and other nematode-susceptible crops. Such fields must be avoided, since nematode-infested tomato plants do not bear nearly as well under Indiana conditions as nematode-free plants. Home garden sites or truck garden patches are unsafe places in which to grow transplants as these locations are invariably infested with various tomato diseases.

Plants grown in the open should be pulled and transplanted as soon as they reach the proper size and condition. If they are allowed to become starved, due to exhaustion of readily available plant food, they become susceptible to the collar rot disease. Plants that must be held in the field for some time after they have reached a size and condition suitable for transplanting should be used with caution, and rejected entirely if any collar rot or early blight is noted in the field.

Control of Diseases in the Tomato Field

It is possible to prevent the introduction of tomato diseases into a field on the seed or transplants. However, practically all of the tomato

diseases of importance in Indiana may persist from one growing season to the next in the soil, or on old plant debris in or on the soil or in perennial and winter annual weeds. Some, such as bacterial spot (Fig. 13) and bacterial canker may persist for only a year or so. Some, as anthracnose (Fig. 12), appear to occur in all soils regardless of whether they have been previously cropped to tomatoes. The organism causing *Fusarium* wilt persists almost indefinitely in the soil once it is introduced. If much of this disease develops on the tomatoes in a field it renders the field unfit for wilt-susceptible varieties of tomatoes for ten years or more. *Septoria* blight (Figs. 11, and cover page), early blight and the virus diseases occur on relatives of the tomato, such as horsenettle, wild groundcherries and potatoes. Most farm gardens are infested with wilt, *Septoria* blight, and early blight, which may be disseminated to tomato fields in many ways. If abundant rains and moderate temperatures occur during the growing season extensive and destructive epidemics of these diseases may develop from very limited initial sources of infection. Additional control measures, such as crop rotation and spraying or dusting are required to control these diseases when they come from sources other than the seed and transplants.

Crop rotation

The widespread occurrence of the organisms causing several of the tomato diseases often makes rotation of limited value as a control measure. Nevertheless, continuous cropping of a field to tomatoes quickly renders it unfit for further tomato crops because of *Fusarium* wilt. Five years or more should intervene between tomato crops, with legumes, small grains and corn preferred as crops in the rotation. At least one year should intervene between potatoes and tomatoes and all horsenettles and groundcherries should be destroyed, since they serve to carry over certain virus diseases from either tomato or potato crops to succeeding tomato crops.

Spraying and dusting

Experimental evidence indicates that some control of the tomato diseases causing leaf blights or defoliation, and possibly fruit rots also, can be obtained by spraying or dusting the plants with suitable copper fungicides, such as Bordeaux mixture, copper-lime dust, or certain new copper compounds known as "insoluble coppers" or "fixed coppers." There is reason to believe that profitable increases in yields of canning tomatoes in Indiana may be secured if these fungicides are applied with efficient row-crop sprayers or dusters of sufficient size and capacity to insure a relatively low cost per acre per application.

There has been a recent renewal of interest in controlling tomato diseases with sprays or dusts. Results of experimental work now under way may make present recommendations out of date in a short time. For that reason, tomato growers, canners and canners' fieldmen who are interested in the control of tomato diseases by dusting or spraying are urged to write to the Department of Botany, Purdue University Agricultural Experiment Station, Lafayette, Indiana, for more recent

and detailed information than can be given here on spray or dust materials, equipment, and time and methods of application.

The spray materials now available for use on tomatoes all contain copper in one form or another. The most effective of these, from the standpoint of disease control, is Bordeaux mixture, but, unfortunately, it is somewhat injurious to the tomato, particularly in dry weather or when the soil moisture supply is low. The plants are induced to give off or transpire more than the normal amount of water.

Preparation of Bordeaux mixture.—Bordeaux mixture made up at the rate of four pounds of copper sulphate, two pounds of fresh hydrated spray lime and 50 gallons of water has given good results on tomatoes in Indiana. In recent years a powdered form of copper sulphate has almost entirely replaced the crystals for spraying purposes and greatly simplifies mixing. Fill the spray tank about three-quarters full of water, start the engine and sift in the required number of pounds of powdered copper sulphate. Then add the required lime made up with water in the form of a thin paste. The resulting Bordeaux mixture should be used immediately, and the agitator kept going to prevent settling and flocculation.

Other copper sprays.—Recently a number of copper compounds have been developed for use as sprays to control foliage diseases. These include various preparations of cuprous oxide, copper oxychloride, basic copper sulphates, copper hydroxides, etc. They are generally known as insoluble coppers or fixed coppers. They may contain from 25 to 86 percent copper, as compared to copper sulphate which contains approximately 25 percent of copper. No lime is used with these materials on tomatoes, thus avoiding one of the objectionable components of Bordeaux mixture. In making them up as sprays it has been customary to use sufficient insoluble copper compound to give one pound of copper (calculated as metallic copper) in each 50 gallons of spray. This places them on the same copper content basis as the recommended 4-2-50 Bordeaux mixture. In addition, some sticking agent such as clear wheat flour, at the rate of four pounds per 50 gallons, and small amounts of a suitable spreading or wetting agent are used to insure complete coverage and proper adherence to the leaves.

Such spreading or wetting agents include dried skim milk or calcium caseinate, used at the rate of one-half pound per 50 gallons, or several proprietary compounds, used according to the manufacturer's directions.

These new copper compounds are generally less injurious to the tomato plant but they may not be as toxic to the disease-producing organisms. Their development is so recent and rapid that it is not possible to give detailed recommendations here relative to their use as sprays or dusts on tomatoes in Indiana. More detailed information on the use of these and other sprays or dusts may be obtained from the Department of Botany, Purdue University Agricultural Experiment Station.

Copper-lime dust.—Because of the excessive weight of spray machines when loaded, the often inconvenient location of the water supply and the greater investment in spray equipment, there is considerable interest in the application of copper fungicides in dust form on tomatoes. A

modified Bordeaux mixture has given good control of tomato diseases in Indiana. It is known as copper-lime dust and is made up of 20 pounds of monohydrated copper sulphate and 80 pounds of finely ground, hydrated spray lime, or sometimes 25 pounds of monohydrated copper sulphate and 75 pounds of lime. These are mixed together thoroughly and applied with a suitable dusting machine to the plants when they are wet with dew. The dust becomes a true Bordeaux mixture when it becomes wet and will then adhere to the plants and act in a similar way.

Other copper dusts.—The various insoluble copper compounds mentioned above may be used in dust form also. A suggested procedure is to make these materials up in dust mixtures containing six percent of copper, 15 percent of wheat flour and sufficient finely ground talc to total 100 percent by weight.

Spray and dusting equipment.—Fairly complete control of tomato diseases may be secured by applying suitable dusts or sprays with hand sprayers or dusters of limited capacity but of low initial cost if care is taken to cover the plants thoroughly with the fungicide. The excessive time and materials required per acre when these hand machines are used usually make such control too expensive to be profitable. High capacity row-crop spraying and dusting machines, similar to those used so successfully by large-scale potato growers, should be used so that the materials may be applied more efficiently.

There are certain mechanical difficulties involved in the spraying or dusting of tomatoes, due primarily to the spreading nature of tomato vines and the susceptibility of the vines and fruit to injury from the machines. It is suggested that prospective purchasers of spraying and dusting equipment for use on tomatoes confer with the technical and service men of the leading spray and dusting machinery companies. These men have had valuable experience in the design of highly efficient sprayers and dusters for potatoes and should be able to adapt these machines to tomatoes. Special consideration has to be given to booms adapted to the wider spacing of tomato rows, to shields for sprayer, duster and tractor or truck wheels so as to reduce vine injury, and to the capacity of the machines.

Time of application of sprays and dusts.—A definite spray or dust schedule cannot be outlined because different seasons vary in rainfall and temperature and because diseases may start earlier in some fields than in others. In general, it appears that if considerable rain and warm weather occur during late May and through June, the first spray or dust should be applied by June 10 to 15 and repeated at least every ten days until five or more applications have been made. If less than normal rainfall occurs during these months the first application may be delayed until July 10 or 15. The first application usually need not be made before the plants reach the size of a peck measure.

Thorough coverage of as much of the leaf, stem and fruit surface as possible is important. This may be obtained by the use of high sprayer pressure with fine nozzle discs and three nozzles to the row, or efficient dusting machines with nozzles so arranged as to direct the dust towards all parts of the plants.

IMPORTANT TOMATO DISEASES

FUNGOUS AND BACTERIAL DISEASES

Fusarium wilt

Caused by *Fusarium oxysporum* f. *lycopersici* (Sacc.) Snyder and Hansen.

Fusarium wilt of tomato (Figs. 1, 2) occurs throughout Indiana. In the areas where tomatoes have long been grown intensively much of the available land is now infested with the wilt fungus and unfit for growing any susceptible variety of tomato. In many sections of the state, crop rotation has held the disease in check and in areas adjacent to many canning factories substantial acreages can still be obtained practically free of the disease. Due to the general increase in infested soil over the state the time is rapidly approaching when only wilt-resistant and wilt-immune varieties can be grown.



Fig. 1. Mature tomato plant, infected with *Fusarium* wilt, showing the wilting and death of shoots as well as the development of characteristic small knobby outgrowths on the stems.

Symptoms. The disease attacks the tomato plant at any stage of development. The organism enters the young roots and grows up through the water conducting tubes of the stem, producing toxic materials which cause the plant to become yellow, wilt and die. Seedlings usually die within a short time after infection. In older plants a yellowing and

slight wilting of the lower leaves is the first sign of the disease. This may occur on one side or on only one shoot of a plant (Fig. 1). As the wilt fungus advances, the leaves higher up on the stem turn yellow and soon drop off. The woody tissues in the bases of such leaves and in the stems of the shoots are stained brown. These internal symptoms may be seen readily by pulling off a yellowed leaf or cutting through the stem and looking for this characteristic discoloration (Fig. 2).

The wilt fungus frequently passes up the tomato stem and out into the fruits where the brown discoloration of the water conducting tubes in the central part of the fruit may be seen. If the fruit remains on the plant long enough or does not decay first, the fungus may penetrate some of the seeds and thus be disseminated in the seeds. Few such fruits are ever harvested and delivered to the canning factory. The seeds in such fruits, furthermore, are usually small and light so that they are washed out or fanned out during any seed-extracting and seed-cleaning processes. Seed transmission apparently is of little importance so long as a suitable disinfectant is used to kill any *Fusarium* spores that may become attached to the outside of the seed.

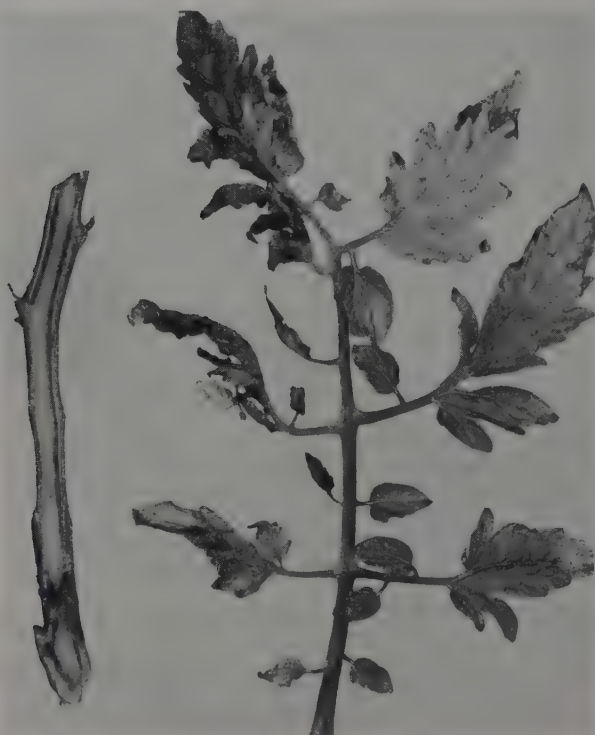


Fig. 2. Symptoms of *Fusarium* wilt in the tomato plant. The cut stem shows the location of the brownish discoloration of the woody tissues, while the leaf shows curvature, and yellowing and death of the leaflets along one side.

Host range.—So far as is known the fungus causing Fusarium wilt of tomato attacks no other host. It will live indefinitely on organic matter in the soil, however.

Control.—Tomato plants usually become infected by being grown in wilt-infested soil. Most garden sites are infested with tomato wilt so that any transplants grown in such a place and subsequently set in the field are likely to be infected with the disease and to infest the field. The disease does not spread from plant to plant in the field to any considerable extent. The soil in which wilt-infected plants grow becomes infested with the organism and is gradually spread throughout a field. If such a field is planted in tomatoes the next year a great many more plants will become infected from the wilt-contaminated soil.

The first step in the control of tomato wilt is the use of wilt-free transplants. Fields should not be cropped to tomatoes oftener than every four or five years and less often than this if at all possible. Fields in which a high percent of wilt-infected plants have grown are usually rendered completely worthless for future crops of tomatoes, unless a resistant variety can be used.

There are quite a number of tomato varieties more or less resistant to Fusarium wilt that will produce fairly satisfactory crops in infested soils. Marglobe, Pritchard, Rutgers, Early Baltimore and Illinois Baltimore are examples. None of these varieties are immune to wilt, however, and may succumb to the disease during hot dry periods. Recent breeding work with tomatoes at Purdue and elsewhere gives promise of the production of new wilt-immune varieties which may be grown successfully on wilt-infested fields.



Fig. 3. Bacterial wilt on a large tomato plant. Note the wilting of the tops of all shoots. This disease is caused by a bacterium which causes a similar wilt of many species of plants. It occurs chiefly in southern states, being found only rarely in Indiana except on tomato plants shipped from the south.

A wilt similar to this frequently appears on tomato plants growing near walnut trees, being caused by a poisonous substance given off by the roots of the trees.

Bacterial wilt

Caused by *Phytophthora solanacearum* (E.F.S.) Bergey et al.

Each year losses approaching 100 percent occur in a few Indiana fields set with tomato plants infected with bacterial wilt (Fig. 3). Since such fields are uncommon this disease is of minor importance in the state as a whole.

Hosts.—Bacterial wilt attacks a wide range of hosts in the southern part of the United States, but is of special importance in causing brown rot of potatoes and Granville wilt of tobacco. Eggplant, Jimson weed, black nightshade and nasturtium also are susceptible to the disease.

Symptoms.—The first sign of infection in the tomato is a rapid, complete wilting of the plant (Fig. 3), quite similar to that which occurs after a close cultivation that cuts some of the main roots. This wilting also resembles that which frequently occurs on tomato plants growing near walnut trees or stumps. Walnut wilt, however, is caused by poisonous substances given off by the tree roots. In contrast to *Fusarium* wilt, bacterial wilt does not cause a yellowing and dropping of the lower leaves. If the stem of an infected plant is cut across at the base the pith may be seen to be darkened and a slight squeeze will cause a slimy ooze to appear. Extensive decay of the pith may also be present (Fig. 4).

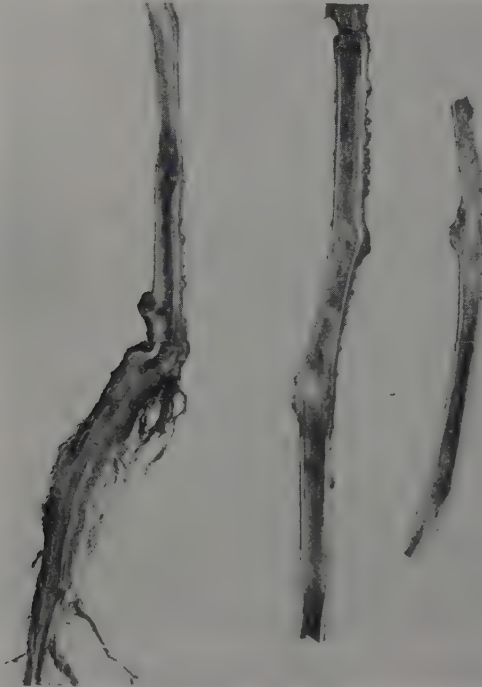


Fig. 4. Symptoms of bacterial wilt on tomato include a soft, brownish rot of the internal tissues of the stem as well as a conspicuous wilting of the tops, followed by death of the plant.

Source of infection.—In Indiana all infected plants noted have been traced to shipments from southern sources. Observations suggest that transplants grown in low, wet areas in newly cleared fields are most likely to be infected. Infected plants appear to be healthy when shipped but develop this disease later when set in northern fields. Plants may begin to show symptoms within five days after setting. Most of the infected plants show the disease within three weeks after setting.

Spread in the field from diseased plants occurs most rapidly during heavy rains when there is considerable run-off of surface water. Insects may cause some spread in the field. In most cases plants showing this disease three or more weeks after setting have become infected after transplanting.

Control.—If a large percentage of the plants become infected soon after setting it is advisable to abandon the field so far as tomatoes are concerned. If only a few plants are found they should be removed. Replants should not be set in the same hole from which diseased plants have been removed.

The wilt-producing bacteria have survived through the winter in the north-central part of the state and have infected tomatoes planted in the field the following season. Legumes, small grains or corn should intervene between tomato crops on land known to be infected with the bacterial wilt organism.

Bacterial canker

Caused by *Phytophthora michiganensis* (E.F.S.) Bergey et al.

Bacterial canker (Figs. 5, 6, 7) has been quite destructive at times in Indiana but careful attention to the production of seed free of the canker bacteria has made it a minor disease. However, it is capable of reestablishing itself and causing serious losses if careless seed-saving methods are used.



Fig. 5. Tomato plant showing symptoms of bacterial canker. The lower leaves first appear scalded and then curl up and turn brown, while the petioles still remain green and attached to the stem. Affected plants are severely stunted or often are killed outright. Serious epidemics of this disease in Indiana are usually traceable to infected seed and transplants.

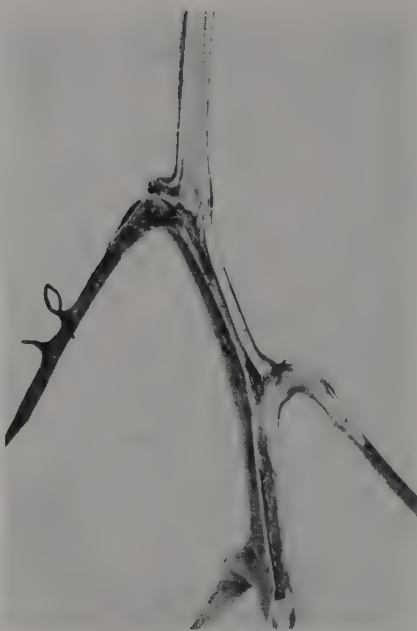


Fig. 6. Split section of a branch of a tomato plant infected with bacterial canker. Note the partially decayed pith in the lower part and the discolored, decayed layer between the pith and wood in the upper part of the section. These decayed areas are frequently of a yellowish or brownish color and of a mealy consistency. The woody part of the stem is not discolored.

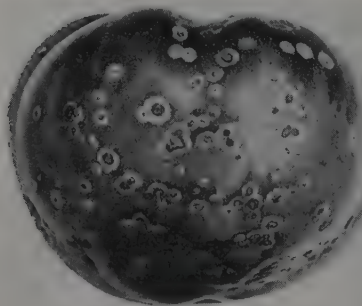


Fig. 7. The birdseye spot symptom of bacterial canker on tomato fruit. This fruit spot phase of the disease occurs rarely in Indiana.

Symptoms.—The disease may attack the plant at any age. Plants infected early may die promptly or remain stunted throughout the season. Sometimes plants infected in the seedling stage may not show the disease until late in the summer. The first evidence of infection on plants in the field is a wilting of the margins of lower leaves. These leaf margins turn brown and roll upward in a manner quite characteristic of the disease (Fig. 5). Usually there is no yellowing of the leaves, and the leaf stems, or petioles, remain green after the leaflets have died, and are not readily separated from the plant. Sometimes small cankers or cracks develop on the stems, from which bacteria may be spattered by rains to leaves and fruits to cause leaf spots and fruit spots. If the stem of an affected plant is split lengthwise, portions of the pith may be found separated from the woody part of the stem by a thin layer of yellowish or light brown decayed tissue of a mealy consistency (Fig. 6). The woody part of the stem usually is not discolored.

This disease may infect the fruit to a limited extent under Indiana conditions, producing small spots with tan centers and conspicuous white margins (Fig. 7). These have been termed "birdseye" spots.

Bacterial canker infection frequently can be traced up through the thin layer of food-conducting tissue between the pith and woody part of the stem and out into the fruits. This infection may extend into

some of the seed. The bacteria may thus be carried internally as well as on the surface of the seed.

Control.—Bacterial canker is best controlled by using seed saved only from canker-free plants. The seed should be treated with a suitable surface disinfectant and planted where the developing seedlings will not become infected from other sources of the disease. The bacterial canker organism may live over in seed bed soils for a year or so, hence such soil should be disinfected or replaced with new soil, or the beds moved to new locations. Insects and driving rains may spread the bacteria, so that plantings of disease-free seed should be well isolated from beds or fields sown with seed of unknown history. Plant growers sometimes top tomato plants when they begin to get too large for good transplants. This practice is rare, but it is certain to spread bacterial canker, if the disease is present in the planting.

Southern root rot

Caused by *Sclerotium rolfsii* Sacc.

This disease is also known as mustard seed rot and occurs widely throughout the southern part of the United States. It attacks a wide range of species of plants, including the tomato. It occurs occasionally on tomato plants shipped into Indiana from southern plant-growing sections but rarely causes much damage. Destructive occurrence of the disease has been noted in southern-grown plants that were heeled in for a time before being set in the field.

Symptoms.—The disease appears as a white mold at the ground line of the tomato plant, and rots away the soft outer part of the stem and the pith, leaving the woody part to support the plant and keep it alive for some time after transplanting. Infected plants finally wilt and die. Small dark bodies about the size of mustard seeds may be found in the decayed stems.

Control.—It is unsafe to heel in southern-grown transplants, since, under such crowded conditions, this and other diseases may spread extensively from only a few originally diseased plants.

Early Blight

Caused by *Macrosporium solani* E. and M.

The early blight disease of tomatoes occurs as a collar rot or stem canker (Fig. 9), leaf spot (Fig. 8) and fruit rot (Fig. 10). All three phases of the disease are destructive in Indiana. The collar rot and stem canker phases frequently occur on southern-grown transplants, causing them to die or to be unproductive when set out. The leaf spot phase is almost as important as *Septoria* blight in causing defoliation. The fruit rot causes many fruits to drop before maturity and is responsible for considerable black decay of ripe fruits.

Symptoms.—Early blight appears on the stems of young tomato plants as small black lesions that subsequently enlarge, elongate, and

sometimes girdle the stems (Fig. 9). Enlarged lesions at the ground line are referred to as collar rot, while lesions higher up are termed stem cankers. Such stem lesions either cause the death of the plant or make it unproductive. Infected plants that survive usually are stunted and rarely mature more than a fruit or two. They commonly fall over early and send out numerous roots from the portion of the stem in



Fig. 8. The early blight disease of tomato attacks the leaves, producing characteristic diseased spots, one-quarter to one-half inch or more in diameter, within which are many concentric rings, producing a "target-spot" effect. Sometimes a conspicuous yellow halo occurs around the killed areas, particularly around lesions on the lower, older leaves.

contact with the soil. This root system rarely develops sufficiently to anchor the plant firmly and supply it with a normal supply of water and soil nutrients.

Early blight appears on the leaves as small, irregular, brownish black spots within five days after infection takes place. These enlarge to from one-fourth to one-half inch in diameter and may be marked with numerous concentric rings or ridges, producing a "target spot" effect (Fig. 8). Early blight spots are rarely as numerous on a leaf as *Septoria* leaf spots but may be much larger.

The early blight fungus frequently attacks the green stems of tomato fruits, producing typical stem cankers. Infection passes from there into the fruit where a dark, rather dry stem-end rot is produced (Fig. 10) that may involve some of the seed cells and penetrate a few seeds.



Fig. 9. Collar rot phase of the early blight disease on the stems of young tomato transplants. Such transplants either die shortly after being set out or develop into prostrate, stunted, unproductive plants.

together in the seed bed or plant field or because of being loaded with fruit.

Control.—Transplants showing early blight infection, particularly stem infections, should not be set in the field. Plant beds, plant fields or shipments of transplants in which many infected plants are noted should be discarded entirely, since many more plants may be infected with the disease and not show it until two or more weeks after being set in the field. Tomato plants that have been held in the beds or fields for some time after they have reached a size and condition suitable for transplanting should be used with extreme caution, if at all, as they may be infected with collar rot.

The leaf spot and fruit rot phases of the early blight disease are less destructive in fields of high, well balanced fertility. They may be controlled to some extent by copper sprays or dusts.

Sources of infection.—Early blight of tomato may be transmitted in some of the seeds saved from fruits infected with stem-end rot. It has been found, however, that practically all such fruits are sorted out and discarded in canning factories, so that if seed is saved only from fruits suitable for canning, internally infected seeds are practically eliminated. The early blight fungus is widespread, occurring naturally in all parts of Indiana, and is undoubtedly present on all farms, regardless of previous tomato crops. It attacks potatoes and other relatives of the tomato. Development of the early blight disease is dependent upon the occurrence of suitable weather conditions when the tomato plants are in a relatively starved condition, either because of being crowded

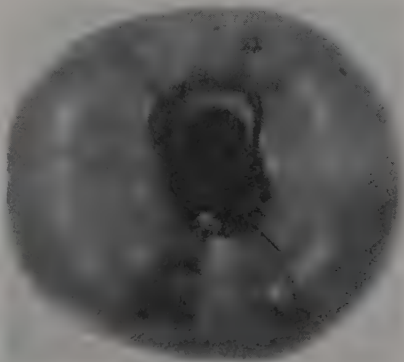


Fig. 10. The early blight disease of tomato on green fruits. Infection takes place in the fruit stems and passes into the fruits where it produces a dark, rather dry rot. The dark lesions are sometimes marked with concentric rings.

Septoria Blight

Caused by *Septoria lycopersici* Spegg.

Septoria blight (Figs. 11, and front cover) is one of the two most important diseases causing serious defoliation of tomato plants in Indiana. In seasons of normal or excess rainfall and moderate temperatures this disease causes the death of tomato foliage, thus weakening the plants, reducing yields and exposing the fruits to sunburn.

Symptoms.—Small water-soaked spots first appear on the lower leaves. These may enlarge to one-fourth inch in diameter, but average considerably smaller than those produced by the early blight fungus, which is the other important defoliating disease in Indiana. The mature Septoria leaf spots are gray and circular, with a dark brown border (Fig. 11). Often, a yellow or pale green halo surrounds the spots. In 10 days or less, small black specks appear in the centers of the spots. These are

the small bodies in which the spores are produced. When these fruiting bodies are mature and become wet the spores ooze out in masses. The spores are then spattered about by rains and produce new infections on still higher leaves. Under favorable conditions the disease will continue to attack successively younger leaves until only small tufts of leaves remain on the tips of the shoots.

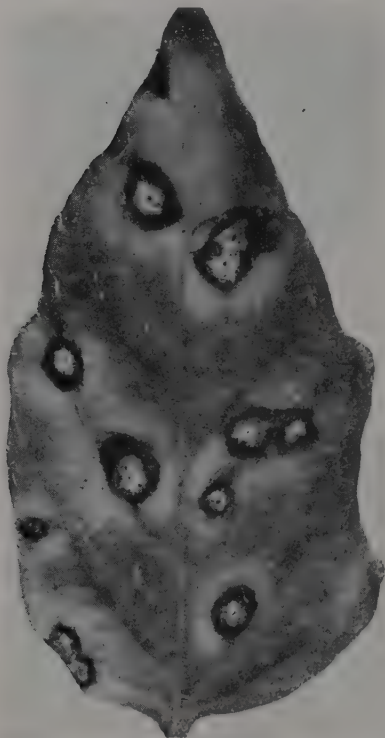


Fig. 11. Septoria leaf spots on tomato leaflet, enlarged about four times. Note the small, black fruiting bodies or pycnidia which contain the spores of the fungus causing the disease. Each pycnidium contains several thousand spores that ooze out and are spattered about by rains. Also see cover page.

Other hosts.—The fungus causing Septoria blight of tomato also attacks nightshade, horsenettle, groundcherry and Jimson weed. For this reason the fungus probably is widespread. Careful systems of rotation and of growing transplants free of Septoria infection often seem to be of no avail against this disease, particularly in rainy seasons, primarily because serious epidemics may develop from even very limited inoculum originating on these weeds.

Control.—The Septoria fungus may live over in old plant

debris, but will not survive burying in the soil. Accordingly, plowing under all infected material will reduce the amount of inoculum that may overwinter and infect a succeeding crop. Long crop rotations including legumes and the cereals may free fields of the fungus, particularly if the susceptible weeds are also carefully controlled.

Spraying or dusting with copper-containing fungicides will control this disease. Whether such control will be profitable depends upon the efficiency with which the fungicides are applied and the productivity of the soil. It is likely to prove profitable in years when conditions are favorable for the disease and in fields located on productive soils.

Leaf Mold

Caused by *Cladosporium fulvum* Cke.

Leaf mold is a serious disease of tomatoes in the greenhouse but occurs only infrequently in the field. It is favored by a humid atmosphere and its control in the greenhouse depends upon proper ventilation so as to provide for air circulation and reduction of the relative humidity. It rarely is sufficiently serious in the field to warrant special control measures. It may occur in low-lying portions of fields, and sometimes occurs very late in the season during or following rainy weather.

Symptoms.—The disease first appears as yellow spots with indefinite margins on the upper surfaces of the leaves. On the underside the spots are purplish with a velvety surface composed of spore stalks and spores. These spores are blown or splashed on to new leaves and, under humid conditions, new infections take place abundantly. Infection of the green sepals at the stem end of the fruit is quite common. If such infection occurs when the fruits are small it proceeds into the fruit causing them to be misshapen. Seeds may be invaded by the fungus, but since few infected fruits are harvested and used in manufacture it is unlikely that any infected seeds ever get into seed lots properly saved.

Anthrachnose

Caused by *Colletotrichum
phomoides* (Saac.)
Chester

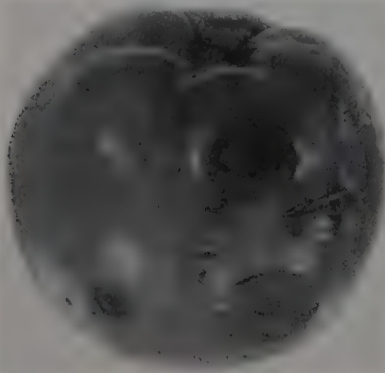


Fig. 12. Anthracnose on ripe tomato fruits. Note the depressed, saucer-shaped, decayed spots with dark concentric rings.

Anthrachnose (Fig. 12) is the most important tomato fruit rot in Indiana. When excessive rains occur during the harvesting season losses from this disease may approach or exceed the loss caused by defoliation. The rot advances so rapidly after infection that unless the fruit is harvested immediately it soon becomes a total loss.

Symptoms.—The fruit is not susceptible to infection until

just before it begins to ripen. Any infection occurring on such "mature green" fruits progresses very slowly until they begin to color. The casual fungus may enter through the surface of healthy, uninjured fruits. Small, circular, sunken, watersoaked spots appear on the surface. At first they are the same color as the surrounding healthy tissue, but soon become darker and the centers of the spots become yellow. In a few days numerous small black specks appear in the dark areas. These are the bodies in which the fungus spores are produced. Under moist conditions pinkish masses of spores appear on the surface of the spots, are splashed about by rains and infect surrounding fruit.

Control.—The fungus appears to be present in most Indiana soils, regardless of whether tomatoes have previously been grown thereon. Tomatoes on infertile soils and in poorly drained parts of fields seem to be more subject to anthracnose. Thus, proper fertilization and good drainage help to reduce losses from this disease. Care should be taken to harvest all ripe fruits at each picking, as they are likely to become badly infected in another week. Spraying or dusting with a suitable copper fungicide has been found to control anthracnose to a considerable extent.

Bacterial Spot

Caused by *Phytomonas vesicatoria* (Doidge) Bergey et al.

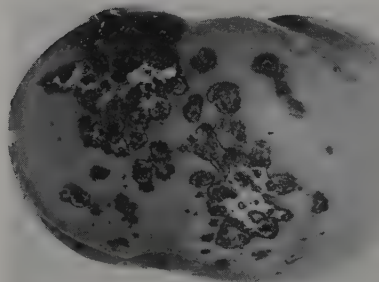


Fig. 13. Bacterial spot on tomato fruits. Note the corky or scabby spots. Infection takes place in the very young fruits and the spots enlarge as the fruits grow. The bacteria causing this disease may be carried on the surface of the seed, but infested seed does not appear to be the only source of the disease.

Bacterial spot (Fig. 13) occurs on young seedlings, on plants in the field and on the fruits. In seasons of abundant rainfall it is quite destructive in Indiana.

Symptoms. — On young seedlings the disease first appears on the seed leaves, true leaves and stems as small, dark spots with a greasy appearance of the upper surfaces. The spots on the leaves develop papery centers that may crack open. These spots can be distinguished from *Septoria* leaf spots by the absence of the small black specks or pycnidia produced by the *Septoria* fungus. Similar spots appear on the stems, leaves and fruit stems and on the sepals of older plants. The leaf spot phase is sometimes responsible for considerable defoliation or dropping of lower leaves. Infections on the pedicels and sepals of the flowers cause many blossoms to drop.

This disease is most conspicuous on the fruits. Infections on the very young fruits appear first as small watersoaked spots of a darker green color. These enlarge as the fruits develop, finally appearing as scabby dark colored areas one-eighth to one-quarter inch in diameter,

extending only slightly into the fruit tissue. Infection does not occur on mature or nearly mature fruit.

Conditions favoring the disease.—Spread and infection usually occur during heavy driving rains. Insects may spread the disease to a minor extent, and it may live over in the soil from one season to the next, but apparently does not persist there for many years.

Other hosts.—This disease frequently occurs in abundance on peppers, and has been transmitted artificially to other relatives of the tomato.

Control.—The scabby lesions on the tomato fruit are full of bacteria which may become smeared on the seed during seed extraction and thus may be seed transmitted. It is necessary, therefore, to treat tomato seed with a suitable disinfectant, such as mercuric chloride, copper sulphate or ethyl mercury phosphate, to rid it of surface-borne bacterial spot organisms. Since the disease may persist in the soil from one season to the next, or may occur on other hosts, particularly pepper, it is essential that the treated seed be sown in disinfected soil or soil that has not been contaminated from other possible sources of the disease. The use of clean seed and clean plants apparently is the most effective means of control.

Buckeye Rot

Caused by *Phytophthora parasitica* Dast.

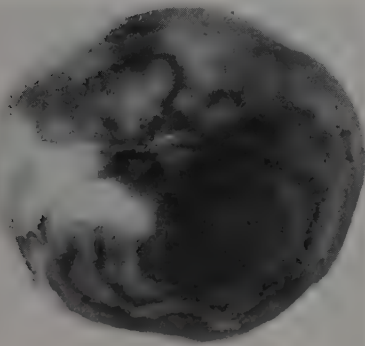


Fig. 14. *Phytophthora* rot or buckeye rot of tomato. Note the concentric rings, suggestive of a buckeye. Green fruits are attacked. The disease occurs mostly in rainy seasons in Indiana.

Buckeye rot is uncommon on canning tomatoes in Indiana but often is a serious disease in home gardens during warm moist weather.

Symptoms.—The fungus causing this disease will attack either green or ripe fruits. Infection takes place through the uninjured skin at the point of contact with the soil or where the fungus has been splashed by rains to fruits several feet from the soil. A small grayish or pale brown spot first appears, which commonly is later surrounded by irregular concentric brown and grayish rings, producing the

“buckeye” symptom (Fig. 14). These rings are often lacking when conditions favor the rapid development of the rot. The surface of the infected area is smooth and the fruit retains its shape. The rot is firm on green fruits, becoming soft as the fruit ripens. A gray mold may appear on the rotted areas.

Control.—Adequate drainage should be provided, since the disease usually occurs in low wet areas in the field. Spraying with a copper fungicide has been found to protect the fruit from infection under greenhouse conditions.

Other hosts.—The fungus causing buckeye rot of tomato also attacks many other species of plants, including eggplant, pepper and cucumber.

Soil Rot

Caused by *Rhizoctonia solani* Kühn.

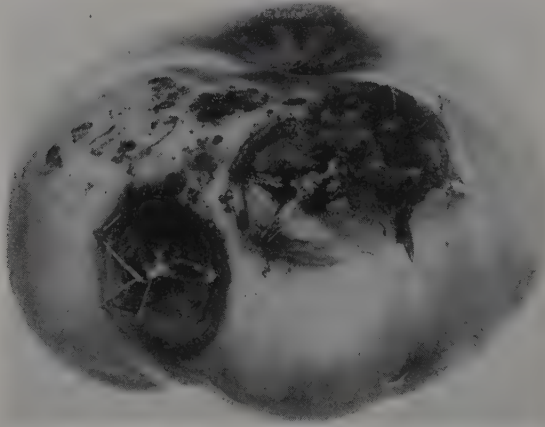


Fig. 15. Soil rot of a tomato fruit. Infection takes place through portions of the fruit in contact with wet soil.

Tomato fruits under heavy vines and in contact with wet soil may become infected with the soil rot disease (Fig. 15). This disease causes some damage to canning tomatoes in Indiana in wet portions of fields and during periods of wet weather.

Symptoms.—Small, circular, brown spots first appear on the lower surfaces of the fruit. These enlarge to an inch or more in size and may show alternating zones of light and dark tissue and radiating cracks.

Control.—Providing adequate drainage will reduce losses from this disease, except in prolonged periods of wet weather.

TOMATO VIRUS DISEASES

All of the diseases described so far are caused by fungi and bacteria. These are living organisms, the individual cells or units of which may be seen through the microscope. Another group of diseases known as virus diseases also occurs on canning tomatoes in Indiana. They are caused by submicroscopic agents that exist and multiply in the juices

of the plant. Usually they are present in the juices in all parts of the plant. They may be spread from plant to plant in any way in which infectious juice, even in minute amounts, may be introduced into minute wounds. In nature, sucking insects are the chief transmitters of the diseases. All of the recognized virus diseases of tomatoes in Indiana may be spread from plant to plant by rubbing juice from a diseased plant on to the leaves or stems of healthy plants. Some are more easily transmitted in this manner than others, and consequently are especially abundant in plants that have been grown in greenhouses or hotbeds and that are handled to a greater extent than field-grown transplants.

There is a wide variety of tomato virus diseases, caused by an unknown number of distinct viruses. Tomato mosaic, ring spot, streak and fern leaf are probably the most important on tomatoes in Indiana.



Fig. 16. Tomato leaves showing malformation of the leaflets and a mottling of light green and dark green as the result of infection with the virus of the green mosaic of tomato and tobacco.

Mosaic

Mosaic is the most abundant and probably most destructive virus disease of canning tomatoes in Indiana. The greatest losses caused by it usually occur in fields set with transplants grown in greenhouses and hotbeds, and which have been handled or crowded considerably before setting out. Occasionally, it is noted in considerable abundance in fields containing a great many wild groundcherries and horsenettles. These plants are susceptible to the disease and carry it over from one season to the next.



Fig. 17. Yellow mosaic of tomato, characterized by conspicuous yellow mottling, puckering and malformation of the leaves.

Symptoms.—Typical mosaic appears on the tomato leaves as irregularly distributed areas of light and dark green tissues. The light green tissues grow or expand less than the darker areas, which results in more or less marked leaf malformations and distortions (Fig. 16). Some strains of tomato mosaic produce only barely detectable symptoms, whereas others produce a brilliant yellow blotching of the leaves (Fig. 17) or extreme leaf malformations. Symptoms of mosaic appear only on those plant parts that develop after infection takes place. Plants infected when quite small may be seriously injured by the disease, whereas plants infected after harvest begins may produce a full crop of fruit.

Sources of mosaic infection.—Small amounts of tomato mosaic virus are present in most cigars, cigarettes, and pipe tobacco, since this disease occurs on tobacco as well as on many other plants. Workers who get moistened tobacco from such sources on their hands may spread mosaic to tomato seedlings. Chewing tobacco is rendered practically free of virus by manufacturing processes.

Wild groundcherries and horsenettles are the chief sources of mosaic infection in the field and the disease is frequently abundant and destructive in tomato fields containing many such weeds.

The tomato mosaic virus can be demonstrated on many lots of tomato seed, since the seed is frequently saved from fields containing a high percentage of mosaic-infected plants. For some reason, not yet well understood, very few infected seedlings develop from such seed. Even so, under crowded greenhouse, hotbed and coldframe conditions one rare seedling infected from seed may serve as an important source of the disease.

Control of tomato mosaic.—The most practical control of tomato mosaic in canning tomatoes in Indiana is secured by the use of mosaic-free transplants and by planting in fields that are free of perennial weeds, particularly wild groundcherries and horsenettles. Growers of greenhouse, hotbed or coldframe plants must keep in mind the fact that tomato mosaic is very easily spread in any way in which even minute amounts of infectious juice may be introduced into minute wounds in leaves or stems. Under crowded conditions plants may become in-

fectured by rubbing against diseased plants. Workmen may touch diseased plants and spread the virus to other plants. Thorough washing of the hands with soap and water will practically free them of virus. Washing the hands at frequent intervals while transplanting small seedlings serves to reduce the amount of spread of mosaic.

Field-grown transplants usually are practically free of mosaic infection because they are grown under less crowded conditions and are handled less.



Fig. 18. Mottling and necrosis of the outer portions of leaflets of a tomato leaf infected with a virulent strain of the so-called healthy potato or latent potato virus. This virus is present in all tubers and plants of all of the old, established American varieties of potatoes but produces no disease symptoms on either the plants or tubers. It can be transmitted readily to tomato by rubbing potato juice into minute wounds in the tomato leaves.

Streak

All tubers and plants of most, if not all, of the old standard American varieties of potatoes are infected with a virus which produces no appreciable disease of the potatoes. However, a distinct but mild mosaic disease results when juice from such potatoes is rubbed into minute wounds in tomato (Fig. 18). This mosaic is usually not serious but when tomato

plants become infected with both the common tomato mosaic virus and this so-called healthy potato or latent potato virus a severe disease develops (Fig. 19). Because of the streaking of the stems, this disease is called tomato streak. It also kills portions of the leaves in the early stages of the disease. New growth that develops after infection has established itself is much distorted, puckered, and mottled. The parts of the plants that develop after infection takes place are rendered worthless.



Fig. 19. Tomato streak, a double-virus disease caused by a mixture of the tomato mosaic virus and the so-called healthy potato virus. Note the necrotic streaks on the stem and petioles. Portions of the leaves are also killed. After the onset of the disease all younger leaves develop a severe mosaic mottling, leaf puckering and leaf distortion.



Fig. 20. Tomato leaf showing symptoms of tomato ringspot. Note the tortuous, necrotic ring-and-line patterns that follow along the small veins. This disease also appears as a blight of the tips of young shoots on plants in late summer.

This double-virus disease is easily spread by the transplanting, pruning and staking operations involved in growing greenhouse or market garden tomatoes, and once started usually spreads rapidly throughout the plantings. Most greenhouse and market garden outbreaks of the disease may be traced to the handling of cut potato tubers or of potato

plants by the workers. The disease does not occur very often in fields of canning tomatoes, but may be found on tomato plants adjoining rows or fields of potatoes, provided mosaic is also present in the tomato plants.

Control of tomato streak.—To control tomato streak it is necessary for workmen to avoid handling cut potato tubers, or potato plants prior to working with tomato plants and to avoid planting potatoes adjacent to tomatoes that may have tomato mosaic.

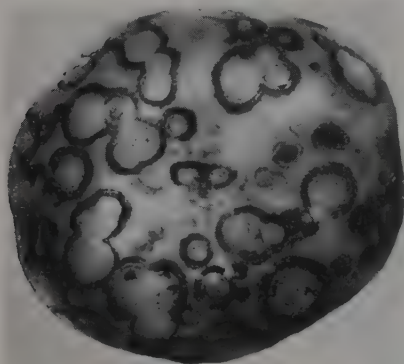


Fig. 21. Tomato fruit conspicuously marked with corky, ring-shaped lesions and picked from a plant showing symptoms of the tomato ringspot disease. Typical ringspot symptoms developed on the leaves of young tomato plants inoculated with juice from such fruits.

Ringspot

A peculiar tomato virus disease often occurs extensively late in the summer in canning tomatoes in many parts of Indiana and particularly in the southern half of the state. It has been termed tomato ringspot and is characterized by the production of conspicuous brown ring patterns on the leaves and fruit (Figs. 20; 21), as well as by a streaking of the tomato stems. Sometimes it is severe enough to cause a blighting of the tips of young shoots. Since the disease appears late in the season it does

not seem to cause a great deal of damage. It also occurs on wild groundcherries and horsenettles, and these plants undoubtedly serve as sources of the disease. It is not easy to spread the disease by rubbing juice from infected tomato plants on to leaves of healthy plants. Apparently some unknown insect is responsible for spreading it in the field.

Fernleaf

The virus of cucumber mosaic also infects tomatoes, sometimes producing a very mild mottling and sometimes a striking malformation of the leaves (Fig. 22). More than the usual number of leaflets develop on some leaves, producing the so-called fernleaf symptom. Other leaves are reduced to string-like forms. Plants showing this type of symptom are usually unproductive. On the whole, the disease causes little loss in canning tomatoes. Many perennial weeds serve as sources of this disease. It is spread mostly by plant lice. The disease may cause considerable trouble in fall crops of greenhouse tomatoes, since cold weather forces many lice to move from weed hosts of the virus to tomatoes in the warmer environment of the greenhouse.

MISCELLANEOUS TOMATO DISEASES

Damping-off

Tomato seedlings may be attacked by various fungi, including species of *Rhizoctonia*, *Phytophthora*, *Fusarium*, and *Pythium*. The young seed-

lings may be infected and blighted before they emerge, or they may become infected at the ground line after emergence and subsequently topple over. This trouble is often spoken of as damping-off since it usually occurs when the surface of the soil about the young seedlings is excessively wet.

Overcrowding and overwatering of seedlings encourages infection by damping-off fungi. The soil may be freed of these organisms by disinfection, either with steam and other forms of heating, or by treating the seed and soil with certain chemicals. Tomato seeds treated with cuprous oxide or soaked in copper sulphate solution are much less subject to damping-off than untreated seed. If damping-off appears in the plant bed after the seedlings are up, new infections can be prevented by drenching the beds with any one of the several copper spray materials, made up to contain one pound of copper in each 50 gallons of water.



Fig. 22. Extreme malformation of the leaves of a tomato plant infected with the cucumber mosaic virus. This virus disease occurs frequently on greenhouse and staked tomatoes but is rarely found in canning tomatoes in Indiana.

Root knot

Caused by *Heterodera marioni* (Cornu 1879) Goodey 1932

Root knot of tomatoes is caused by a minute nematode or eel worm that also attacks the roots of a great many other species of plants. The soils in many Indiana greenhouses are infested with this nematode, and it occurs in many sandy soils in southern states. Tomato trans-

plants grown in such greenhouses or in such infested sandy soils become infected. It is known that tomato plants showing root knot infection are quite unproductive but it is not known how destructive the disease is in Indiana canning tomatoes. For some obscure reason, tomato transplants grown in nematode-infested soils frequently do not develop serious root knot when set out in soils in this state. However, if such plants show visible root knot when set out the disease continues to develop and to cause considerable injury.



Fig. 23. Roots of young tomato transplants showing the small swellings or nodules produced by the root knot nematode. These swellings continue to enlarge as the roots grow, stunting the plant and making it unproductive. The root knot nematode is common in many sandy soils of the Gulf coast states and also occurs frequently in greenhouses in Indiana. It attacks many different species of plants. Tomato transplants should not be grown in nematode-infested fields nor should infested transplants be set in the field.

Symptoms.—Root knot appears on the roots of young tomato transplants as small swellings or nodules (Fig. 23). Many roots bearing these nodules are broken off and left in the plant bed or field when the plants are pulled for transplanting and such plants may appear free of nematodes. Invisible infestations may be present on the remaining roots, however. As the plants grow the infections develop into large irregular growths or root knots (Fig. 24) that seriously interfere with the proper functions of the roots.

Control.—Tomato transplants should not be grown in soils known to be infested with nematodes, nor should plants be accepted and set out that show the small nodules or swellings. Greenhouse soils can be

freed of nematodes by steam disinfection. Infested field soils may be detected by examining the roots of nematode susceptible plants, such as tobacco, cotton, sweet potatoes, etc., growing in such soils.



Fig. 24. Roots of mature tomato plants showing root knot caused by the root knot nematode. Root knot renders tomato plants unproductive under Indiana conditions.

Blossom-end rot

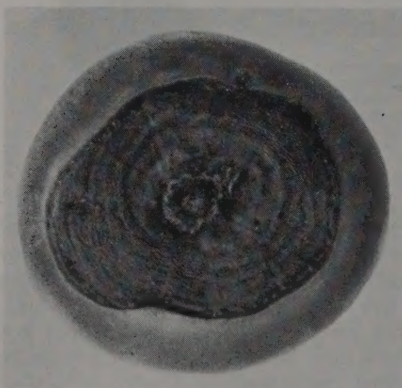


Fig. 25. Blossom-end rot of tomato fruits. This appears as a dry, leathery rot of the blossom end of the tomato and is mostly the result of a sharp decrease in the soil moisture supply.

Blossom-end rot is a disease that develops on greenhouse and field-grown tomato fruits under certain environmental conditions and often is responsible for considerable loss. It is not caused by any disease-producing organism.

Symptoms.—A small water-soaked spot first appears at the blossom-end of the fruit. The spot increases in diameter and becomes sunken, due to shrinkage of the affected tissue (Fig. 25). The rot is firm and leathery. Often decay-producing organisms invade the affected regions and produce a soft rot. The oldest and youngest fruits appear to be more

resistant under conditions favoring the disease.

Cause and control.—An irregular supply of soil moisture appears to be the principal factor favoring the disease under field conditions. Any long period of drought following a period of high soil moisture supply induces the disease. It often occurs on sandy soils and on freshly manured land. Any practice that will help to give the plants an even supply of moisture, particularly in the early part of the fruiting season, should reduce the amount of blossom-end rot.

Cloudy spot



Fig. 26. Cloudy spot occurs as white, tough or fibrous spots under the skin of the tomato fruit.

In some years many tomato fruits are noted which have irregular white spongy or corky spots under the skin. These spongy, colorless areas may be small or they may involve considerable portions of the wall of the fruit. This condition, called cloudy spot (Fig. 26), is caused by the feeding of stink bugs, and possibly related insects, on either the green or ripe fruits. This injury is not to be confused with the discoloration on the surface caused by tomato mosaic or nutritional disorders.

Walnut wilt

Tomato plants growing in the vicinity of walnut trees or stumps of recently felled walnut trees frequently wilt and sometimes die. This wilting resembles that caused by bacterial wilt but it apparently is caused by some poisonous material produced by the roots of walnut trees.

Lightning injury

Lightning sometimes strikes in tomato fields, killing plants in more or less circular areas 10 to 30 feet or more in diameter. Tomato plants on the edges of such areas may appear scorched and some shoots may be killed. Brown, dead streaks may be noted on some stems, which may also be hollow.

